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A STUDY OF SPATIAL ORIENTATION OF CHILDREN*

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Editor's note: Spatial orientation is a matter of general concern since all of us live and move about in a world of fixed objects: The author presents a study of the spatial orientation of school children in the later elementary school grades.

ALL of us live in a world of objects many of which have fixed positions. We are continually reacting to the spatial patterns formed by these objects. The family residence is at the *corner* of the block, the grocery is *opposite* the fire station, the lost tourist is instructed to go one block *west* and two blocks *north* to reach the hotel, the sun appears in the *eastern* sky, etc. Presumably our happiness and our success are in part dependent upon our ability to gain control over the spatial patterns of the objects with which we come in contact in our daily activities and to move efficiently among them.

The investigation herein reported had for its purpose the study of the ability of children in the later elementary school grades to exhibit spatial orientation. By spatial orientation is meant

. . . the localization of objects in imagination either with reference to oneself, to one another, or fixed, standard directions.¹

It will be noted that three methods of localization are suggested in Freeman's definition, namely—location of objects with reference to oneself; location of one object with reference to a second object, the location of which is assumed to be familiar; and location of objects by use of a system

* Abstract of a dissertation submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in the University of Michigan. (April 1936)

¹ Freeman, Frank N. *Psychology of the Common Branches* (Boston: Houghton Mifflin Co., 1916), p. 164.



of fixed directions. According to Freeman the genetic development of orientation follows a series of stages which approximates the order in which the methods were just presented.

The study concerned itself with the measurement of the ability of children to deal with three phases of spatial orientation. First, ability to designate directions in space; second, ability to describe the spatial arrangement of familiar places, streets, etc. in terms of the conventional system of fixed direction and in terms of location in space with reference to the subject; third, ability to maintain one's orientation during travel. A more detailed description of the test will be given in later sections.

The writer has collected numerous statements from parents and teachers which describe their difficulties in orientation. According to their testimony, defective orientation seems to be traceable to the persistence of incorrect patterns developed in the elementary grades. For the most part these patterns were developed in fixed situations: i.e. several years of school experience in a seat which faced east, or years of instruction from a map which hung on south walls on a schoolroom. The attitude of an adult who is confused in habits of orientation and the common remedy is well illustrated by the following letter which was received by a county school commissioner in Southern Michigan.

Dear Mrs. -----:

When a child I attended this same school, and when it came to geography got mixed on directions. Then a county school com. was the instigator of refurnishing and reseating the school house, the seats facing north. The school house burnt not long after and the present one was built. The officers, much like Will Carleton's *The School Master's Guests*, insisted on putting the seats back as in the other house. Would there be any way the pupils could face north while studying their lessons in geography. Should this be out of place, please excuse it and do not mention it.

Sincerely interested

Grandma -----

The importance of developing ability to orient oneself correctly has long been stressed in geography textbooks. As early as 1813 Cummings prefaced his first book as follows:

In teaching geography, let the pupils sit (sic) with their faces toward the north. Trifling as this may appear, it is of great importance -----
----- Learners should always be required, for a considerable time at least,

to point out the place asked, either with their finger, or something else they may hold in their hand for the purpose.¹

Later nineteenth century textbooks used illustrations to help children fix directions in mind; for example, pictures of the compass or an arrangement of lines to represent the compass points. The association of directions with bodily positions illustrated by the use of pictures was used. The following excerpt from old texts are typical of the latter method:

If you stand with your right arm towards the East, West will be on your left hand, North will be before you and South behind you.²

PREVIOUS STUDIES

A survey of the literature on the general topic of orientation reveals that the majority of articles deal with some phase of teaching directions to children. A few studies are available, however, which do report attempts to measure the ability of either children or adults in dealing with directions. The particular studies which have a direct bearing upon the present investigation are summarized here. For convenience of discussion they are grouped under the following headings: (1) Studies with adults as subjects; (2) Studies with children as subjects.

Studies with Adults as Subjects

Perhaps the most important and the most scientific study in the field under discussion was carried on by Trowbridge and financed by the New York Academy of Science.³ His purpose was to study the methods of orientation used by adults. He introduces his article with the general statement that

... there appears to be two radically different methods; one used by civilized man, the other chiefly by living creatures of a lower order. The former, which employs the points of the compass, is acquired artificially by education. It is proposed to call this the *ego-centric* method. The latter is used not only by birds, beasts, fish, insects, etc., but also, in all probability by young children and by a large proportion of mankind living in an un-

¹ Cummings, J. A. *Introduction to Modern and Ancient Geography* (Boston: 1813), p. 114.

² Warren, D. M. *Common School Geography* (Philadelphia: Cowperthwait and Company, 1868), p. 6.

³ Trowbridge, C. C. "Fundamental Methods of Orientation and Imaginary Maps," *Science*, XXXVIII (Dec. 19, 1913), pp. 888-897.

civilized state. In this system of orientation, the points of the compass play little if any, part and it may be designated as the *domi-centric* method.¹

Trowbridge's data were collected from sketches made upon large circular pieces of paper. New York City was represented in the center of the circle and each subject located several distant places with reference to it. Graduate students and college teachers were used as subjects. Trowbridge analyzed the sketches made by his 27 subjects and worked out the apparent arrangement of places as imagined by each.

These imagined patterns which he terms "imaginary maps" are to be distinguished from the correct patterns which are recognized by an individual if he reflects a moment. Trowbridge reported finding four major types of imaginary maps among his subjects: (1) Persons of a fairly consistent deviation from the correct directions for the entire circuit of the compass; (2) persons with different imaginary maps in different localities; (3) persons who imagine north as always being directly in front of them; (4) persons who imagine that all distant points lie either west or east of them. Trowbridge estimates 30 to 50 per cent of adults possess incorrect imaginary maps.

Ridgley reports having interviewed numerous teachers relative to the ease with which they used directions.² He estimates that fully 95 per cent experience considerable difficulty. It is his opinion that, in most cases, the difficulties were traceable to poor teaching.

Studies with Children as Subjects

Gulliver reported in 1908 an informal investigation of children's ability to use directions in map drawing of their immediate school surroundings.¹ He did not report the details of his investigation but presented the general conclusion that

Children apparently have no fixed point of orientation which guides them in drawing a map of a known area. They are nearly as likely to put the east or the west to the top as the north. They seldom place the south at the top. Even when they are told where the north and south line lies in the schoolroom, they are generally unable to draw with correct orientation a map of a few streets which they know intimately.²

¹ *Ibid.*, p. 888.

² Ridgley, Douglas. "The Teaching of Directions in Space and on Maps," *Journal of Geography*, XXI (1922), pp. 66-72.

¹ Gulliver, F. P. "Orientation of Maps", *Journal of Geography*, VII (1908), pp. 55-59.

² *Ibid.*, pp. 57-58.

In a recent investigation reported by Howe, 1300 children from kindergarten through Grade VI were used to measure ability to use directions in space and on maps.³ Each child was taken out of doors to the school grounds. Those who were in the kindergarten and Grades I, II, and III were asked to point north and to point east. A record was made of the directions in which they pointed and their reasons for pointing in the particular direction which they believed to be north. As each child returned to his room, he was again asked to point north and to give his reasons. The children above Grade III were given the same tests as the younger children, and in addition they were asked to indicate east on a wall map and to give the reasons for their choice.

The eleven per cent of children who reported that they used natural objects such as sun, stars, etc. in determining directions were more accurate than those who did not. The child's home, contrary to expectations played little part in his knowledge of directions. Over 60 per cent of the reasons for choosing a direction as north were meaningless to the teacher who did the examining. The boys tended to exceed slightly the girls in ability.

Howe followed his investigation with a remedial program designed to develop a clear concept of directions in space based upon sun behavior and to determine the level at which such instruction should begin. He used approximately 300 children in Grades I, II, and III and gave them experiences in observing the position of the sun during early morning, noon, and late afternoon. The pupils were drilled on the directions associated with the positions of the sun. After a ten weeks observation period the pupils were tested nearby and away from the school building, being asked to point out the various directions both in the morning and in the afternoon. Approximately 50 per cent of the children in Grade I, 75 percent in Grade II, and 88 percent in Grade III gave correct responses. Over 90 percent of the answers showed that the children had made deductions with regard to directions and the sun's behavior. Howe concluded that children could acquire a clear concept of directions in space especially in Grade III if proper drill is given out-of-doors nearby and away from the school.

³ Howe, F. George. "The Teaching of Directions in Space", *Journal of Geography*, (May, 1932), pp. 298.

TESTS AND THE SUBJECTS

This investigation has for its purpose the description and interpretation of certain orientational abilities of children in the later elementary grades of rural schools. The types of abilities investigated are suggested by the four major tests used. These were:

- I. Test of orientation with reference to directions in space—or the ability to designate the cardinal and intermediate directions by pointing into space.
- II. Test of orientation with reference to cities in space.
 - Part A. Ability to point in the direction of both distant and nearby cities.
 - Part B. Ability to show by a simple sketch the spatial arrangement of local cities and villages.
- III. Test of orientation in the community.
 - Part A. Ability to indicate the direction of streets.
 - Part B. Ability to give the location of stores, etc.
 - Part C. Ability to indicate the directions seats face in theaters, auditoriums, etc.
 - Part D. Ability to show locations of places in a familiar city by constructing a single map.
- IV. Test of ability to maintain orientation during travel.

It was necessary to evolve a method of recording objectively the responses of the subjects as they pointed out directions in space. The technique used by Trowbridge for testing adults did not seem adequate for use with children. Howe's oral technique is rather slow to be used by a single examiner and perhaps somewhat subjective since the examiner must estimate the direction being pointed out by the subject's gestures.

After much preliminary experimentation satisfactory techniques for individual and group testing were developed. The apparatus for individual testing is shown in Figure I. It consists of a revolving organ stool to the seat of which a pointer was attached and a device for automatically indicating its position. As the seat was revolved and then brought to rest with the pointer in any given direction, an electrical connection was made through a contact point suspended under the seat and touching one of sixteen copper plates. These plates corresponded in arrangement to the cardinal and intermediate directions. Before the stool could be used, it had to be oriented with the aid of the compass in such a way that the copper plates coincided

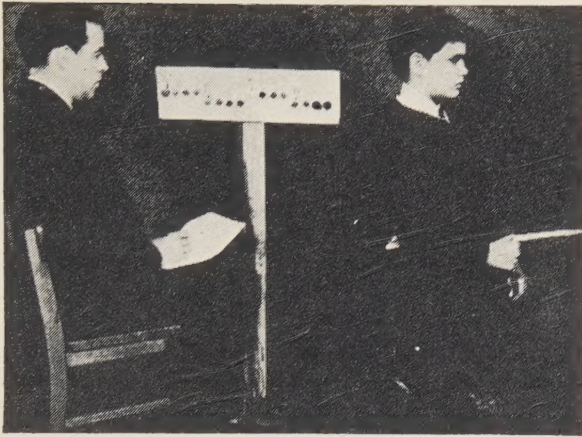


Figure 1. Subject being tested with apparatus used for individual tests of directions in space.

with the directions in space. As the contact point touched any one of the plates a circuit was completed and a light flashed on a panel before the examiner to indicate the direction of the pointer. The apparatus was used for individual testing during a preliminary investigation which provided data to compare with results obtained by the group test.

For group testing a device was worked out consisting of a circular cardboard about fifteen inches in diameter upon which were drawn sixteen arrows arranged like compass points. A pattern of arrows was placed upon each subject's desk in such a manner that the top edge, which was straight, could be placed in a position parallel to the front edge of the desk or table being used by the subject. When so placed, Arrow C pointed in the direction the subject was facing and all the other arrows assumed directions with reference to it. The pattern then was in a fixed position throughout the test. The subjects could respond to questions regarding directions by merely indicating the labels of the appropriate arrows. For example, if a subject facing north, was asked for the letter of the arrow pointing south, she would respond with "P" the label of the south-pointing arrow. A subject using the group test is shown in Figure 2. It was a common thing for the subjects to gesture or point with their pencils or with fingers during the tests which required indication of directions in space.

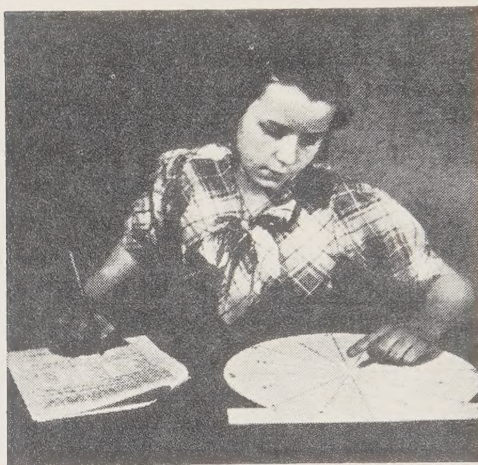


Figure 2. Subject completing a test of orientation with the material used for group testing.

The circular shape was used because it resembled a map less than the rectangular designs, and the arrow appeared more uniformly spaced when corners were avoided. Letters were used in place of numbers to designate arrows because the subjects seemed less disturbed by the jumbled order which had to be used in order to avoid the suggestion of a starting point or a key direction such as north.

Subjects

Excepting the travel test, the group tests were administered to 173 boys and 144 girls distributed rather uniformly through Grades V to VIII inclusive. The subjects were from typical rural schools of southern Michigan. In addition, the individual tests for directions in space and pointing out locations of cities were used with 79 children in Grades IV and V.

Since a familiarity with the communities in which the subjects lived was essential to success in certain of the tests, the years of residence in the community was ascertained from each child. The mean number of years for both boys and girls was 9.1. Over 93 percent indicated that they had lived in the community three years or over.

Since one of the questions raised for investigation was the effect of the direction the subject faced upon his accuracy in dealing with directions, it was important to know how constant the matter of direction faced in school was for the subjects. Therefore, each child was asked the following question: "How many years have you attended this school?" About half the subjects attended their present school a number of years equal to or greater than the number of their present grade, i.e. five years for Grade V, etc. Sixty-five to seventy percent had had all their geography instruction in the school in which the testing was done.

In order to ascertain the instructional background of the subjects, a careful analysis was made of the geography texts used in Grades IV and V. Space does not permit a detailed summary of the finding. There were 309 occurrences of the cardinal directions and 17 uses of the four intermediate directions in the descriptive material of the text for Grade IV. The directions north and south were used three times as often as any other direction. There were 41 occurrences of directions in the same book as a part of an exercise or practice material. In the text for Grade V directions occurred in the descriptive reading matter 896 times and in exercises 80 times. The analysis revealed that the pupils had had varied experiences with directions in their geographical reading which should provide a background for at least certain of the tests.

The use of children from rural schools permitted comparison of abilities of children to use directions when seated in schools which face different directions. Slightly over half the subjects faced south, about a quarter of them faced north and the remaining quarter were rather evenly divided between east and west. The high proportion of north and south facing subjects may be explained by the fact that rooms are usually planned in such a way as to provide light from either east or west.

Miscellaneous data were collected with regard to extent of individual experiences which might have a bearing on performance. Representative questions asked were:

Have you spent most of your life on a farm or in the country?

Are you a member of the Scouts? If so, how long have you been a member?

Do you carry a watch?

Do you carry a compass?

Can you tell directions by using the sun? If so, tell how you do it.

In addition, an attempt was made to ascertain the travel experiences of each child. However, most of the data proved useless since it was impossible to isolate individual experiences in such a way as to have positive evidence of their influence upon performance.

ORIENTATION WITH REFERENCE TO DIRECTIONS IN SPACE

Test I was designed to measure ability to point out directions in space. After placing the cardboard pattern of arrows parallel with the front edge of the desk, the subjects were asked to name the direction eight of the arrows pointed. The eight arrows pointed out the four cardinal directions and the four intermediate directions. The examiner observed the children carefully during the test to make certain that the instructions were clearly understood.

The four main directions were dealt with more accurately than were the four intermediate. The percentage of correct designations for each may be seen in Table I. There was a general improvement from grade to grade except for Grade VIII.

TABLE I
PERCENTAGE OF CORRECT ANSWERS BY GRADES FOR EACH DIRECTION IN SPACE
(Subjects: Grade V-84; VI-103; VII-70; VIII-59)

Directions	Grade				Mean
	V	VI	VII	VIII	
Cardinal					
North.....	58.3	76.7	72.9	74.5	70.6
East.....	75.0	79.6	77.1	77.9	77.3
South.....	71.4	74.7	72.9	77.9	74.2
West.....	73.8	76.7	80.0	76.2	76.6
Intermediate					
Northeast.....	57.1	65.0	81.4	69.4	68.2
Southeast.....	60.7	66.0	75.7	74.5	69.2
Southwest.....	59.4	65.0	80.0	64.4	67.2
Northwest.....	60.7	66.9	72.9	69.5	67.5

The boys as a group were superior to the girls. All eight directions were correctly designated by 55 per cent of the boys, while only 38 per cent of the girls succeeded on all eight tests. The mean number of correct directions for the boys was 6.15 and for the girls 5.08. The critical ratio of the difference was 4.86. The relatively poor performance of the girls is ex-

plained, in part, by the failure of eighteen of them to identify a single direction correctly.

The percentage of subjects who exhibited perfect orientation with reference to the eight directions tested when grouped according to the direction they faced in school was as follows: facing north, 69.2; facing east, 50; facing south, 35.4; facing west, 59.5. The relatively poor scores of the south facing subjects was anticipated by the writer, since this group appeared to be greatly confused while they were taking the test; the confusion seemed to be caused by the fact that their position was reversed 180 degrees from the convenient north-facing position. A position 90 degrees removed from north did not seem to be nearly as difficult to rationalize. An analysis of errors made on the four cardinal directions by the subjects who faced east, south, and west, showed that nearly 60 per cent of the errors were apparently due to a confusion of map directions with space directions: i.e. children facing south tended to say they were facing north, etc.

ORIENTATION WITH REFERENCE TO CITIES IN SPACE

In order to determine the extent to which the children could indicate the location of cities in space, two tests were devised. In one test the subjects were asked to point out the location of 20 cities by use of the pattern of arrows already described. This test was comparable to asking a person to point out locations of cities by gesturing. In the other test the subjects were required to make a simple sketch to show the arrangement in space of a number of cities within a radius of 40 miles.

Pointing out Locations

The test which required pointing out of locations included twenty cities of which ten were in Michigan and the rest were the larger cities of the United States. For convenience of reference the two groups of cities will be referred to as "local" and "distant".

The fore exercise and the oral directions were carefully planned to emphasize that the locations were to be pointed out according to *direct* routes. Practice was given in the use of the arrows in locating nearby familiar places.

In the interpretation of the responses on this test, the question arises as to just what are the limits within which one may consider an answer as being correct. The pattern of arrows used in the test, indicated sixteen direc-

tions, varying $22\frac{1}{2}$ degrees from each other. It seems reasonable to assume that an error of $22\frac{1}{2}$ degrees on either side of the best answer that could be obtained from a map, should be considered as acceptable or correct. This means that a response, to be considered correct, must be within the 45 degree sector in which the true answer is found. For example, if north were the best direction, either north-northeast or north-northwest were also accepted as correct.

In tabulating the data as to the relative accuracy in pointing out the locations the "distant" and "local" cities were considered separately. The locations of the former, the "distant" cities, were undoubtedly learned largely from maps, while locations of "local" or Michigan cities may have been learned from travel and from maps.

Only two of the distant cities—New York and Chicago—in the list were attempted by over 80 per cent of the subjects, the average for the ten cities being 68 per cent. As can be seen from Table II, just one third of the attempted responses were correct. A comparison of the results obtained by the individual technique with those obtained by the group tests show a critical ratio of .10 indicates no significant difference and suggests that the group tests were reliable.

The boys were able to point out more locations than the girls but when accuracy of responses were compared, there was no significant difference.

TABLE II
PERCENTAGE OF SUBJECTS ATTEMPTING AND GIVING CORRECT ANSWERS
FOR THE "DISTANT" CITIES
(Number of subjects—317)

City	Attempted		Correct	
	Number	Percentage	Number	Percentage
Chicago.....	280	88.8	115	36.3
New York.....	262	82.7	99	31.2
St. Louis.....	206	64.9	55	17.2
Pittsburg.....	184	58.1	64	20.2
Denver.....	205	64.7	75	23.7
Boston.....	207	65.8	76	24.0
Los Angeles.....	219	69.1	58	18.5
New Orleans.....	197	62.1	62	19.5
Philadelphia.....	186	58.7	45	14.1
San Francisco.....	211	66.6	78	24.6
Mean.....	215.6	68.0	72.7	22.9

The hesitancy with which the girls responded was apparent during the administration of the test.

The subjects who faced north were twice as accurate in pointing out locations as were subjects seated in any of the other three directions. A comparison was made of the accuracy of the locations made by the subjects when grouped according to the directions they faced during the test. The results of Los Angeles are presented here as representative of the distant cities.

In pointing out the location of Los Angeles, the north-facing subjects were considerably more accurate than the other groups. The three directions, west, west-southwest, and southwest, were designated by over 60 per cent of the subjects of this group. Relatively small percentages were shown for the other directions. There was then a very definite direction associated with Los Angeles by the north-facing group.

The east-facing group divided their answers between a general north-west direction and the southeast direction. Northwest would be expected as the response if the subject considered the direction he was facing as north. This wrong location suggests an "imaginary map" which is based on an error of 90 degrees due to repeated experience in seeing the map with the top to the east. The writer is unable to account for the relatively large proportion of southeast answers.

The placement of Los Angeles by the south-facing group shows the choice of two directions by most of the subjects—east and west. The west placement is satisfactory for this is the correct general direction. The east placement might be interpreted as the result of an "imaginary map." To subjects facing south, Los Angeles appears to the left side of the map. The direction in space to the left of a south-facing subject would be east. There is a definite suggestion here of two main types of "imaginary maps." One coincides with reality and the other is reversed 180 degrees from the true map. The latter type is undoubtedly related to the repeated experience in seeing the map of the United States in a position which is reversed 180 degrees from the correctly oriented map.

The "local" cities were located with slightly greater accuracy than were the distant cities. Table III presents the number and per cent of correct locations for the local cities.

TABLE III
PERCENTAGE OF SUBJECTS ATTEMPTING AND GIVING THE CORRECT ANSWERS
FOR THE "LOCAL" CITIES

City	Attempted		Correct	
	Number	Percentage	Number	Percentage
Detroit.....	301	94.9	171	54.0
Grand Rapids.....	217	68.4	58	18.4
Kalamazoo.....	184	58.0	54	17.0
Port Huron.....	168	51.4	50	15.7
Flint.....	211	66.6	71	22.4
Lansing.....	243	76.6	67	21.1
Saginaw.....	178	56.1	77	24.3
Monroe.....	143	45.1	42	13.2
Jackson.....	247	77.9	114	36.0
Pontiac.....	155	48.9	61	19.2
Mean.....	204.2	64.4	76.5	24.1

The relatively high degree of accuracy in placing Detroit in space is no doubt related to opportunity for actual experiences with spatial relations between the pupils' home community and this city. Experience in travel, experience with directions of main routes, observation of busses en route, etc., all would help to build up place associations.

Observation of the children at work during the tests and the discussion of responses with them afterwards brought out some interpretations worth noting. The strength of "imaginary maps" apparently varies with different individuals. Some of the subjects located places incorrectly and insisted that they were correct; others noticed their errors and corrected the answers before handing their tests to the examiner. There were subjects who used both correct and incorrect "imaginary maps"—the correct one for near-by cities such as Jackson and Detroit, and the incorrect ones for "distant" cities. Frequently such subjects did not recognize that they were using two patterns of arrangements. They were able to "slide" from one to the other without being aware of it.

Locating by Sketching

The second test of orientation with reference to cities in space consisted of having the subjects make a simple map by placing dots and numbers to represent the spatial arrangement of sixteen cities and villages in Michigan. All but six of the places were within a radius of ten miles of the territory in which the testing was done. A dot in the center of the

test paper showed a city which was familiar to all the subjects. This city served as a point of reference for locating the other places. In order to control the factor of distance on the sketch two concentric circles were drawn on the test paper. The instructions listed the nearby places and directed that their arrangement be shown in the inner circle and that the list of more distant places be shown in the outer circle.

In scoring the test a stencil was used for determining the segment, or sector, of the circle in which any given city was placed. The exact center of each segment was one of the four cardinal directions, or one of the four main intermediate points. The top and sides of the stencil were labeled with the correctional map directions. This stencil was placed on top of the test being scored in such a position that the outer circle of the stencil coincided with the outer circle of the test. Then the stencil was turned to the position which represented north in *space* for the particular subject whose test was being scored. For example, if a subject faced south during the test, the north sector of the stencil was placed toward the bottom of the test paper. This procedure was followed in order that a given sector on the stencil would always have the same meaning in terms of a particular direction despite the position of the subject while taking the test.

There were two distinct methods of arranging answers. A subject may arrange the cities according to conventional map directions by considering the top of the page as north, the right as east, etc. Hereafter such answers will be referred to as *map answers*. He may, however, attempt to visualize the locations of the cities as they are arranged in space about him, and place dots and numbers to represent this arrangement. If a subject were facing south, he would visualize Detroit as being to his left and place a dot to represent it on the left side of the page. Ypsilanti would then be represented in a position between Ann Arbor and Detroit. The term *space answers* is used hereafter to refer to such answers. If the subject were facing north, his map arrangement of the cities, and the arrangement as he visualized it in space about him would, of course, be the same.

Nothing in the instructions suggested the use of either method of arranging the cities. Suggestions were deliberately left out in order to ascertain which method the subjects would normally choose. It was hoped that the method chosen might be indicative of the subject's orientation level.

It was not expected that the subjects would be familiar with the location of all the cities, but rather that the list would provide a basis for

representative responses which would indicate whether the subjects had developed patterns of spatial arrangement. Consequently the major concern is not with the number of cities located correctly but with the method of locating and the accuracy of the attempts.

Of the 1,251 responses made by the boys, 8.2 per cent were in the correct map sector, and 12.8 per cent were placed in either of the adjacent sectors. The space answers are distributed—30.5 per cent in the correct sector and 29.3 per cent in the adjacent sectors. Of the 980 responses of the girls 10.5 per cent of the map answers were in the correct sectors and 16.4 in the adjacent sectors. The space answers were distributed evenly—27 per cent in the correct sector and adjacent sectors. It should be pointed out that there are two sectors adjoining the one correct sector, and so, on the basis of chance, the answers placed in the adjacent sectors are not on a par with those in the correct sectors.

The ratio of space answers to map answers is approximately two to one. When space answers were given, a greater proportion of them were placed in the correct sector than were the map answers. Almost twenty per cent of the responses could not be classed as either map or space answers. The girls gave a slightly higher percentage of map answers than did the boys.

The number of subjects who attempted to locate individual cities varied greatly as might be expected. The best known cities were located with less than 50 per cent accuracy. Two children arranged correctly fourteen of the fifteen places, while several were able to arrange only one or two.

It was observed in the previous test that as the subjects pointed out Michigan cities they apparently located them in space without recalling their position on a map. There was little evidence of the "imaginary maps" which were so prominent in the results of the tests on distant cities. The results indicate that a child may locate a city with either of two patterns of directions in mind. If the city is relatively near he may locate it by visualizing its position in space with reference to himself. If a distant city is to be located, he may place it in terms of the particular map position in which he has visualized it from day to day. In the latter case, if he fails to think of the map in an oriented position, he then locates the city in question with an incorrect arrangement of directions in mind.

ORIENTATION IN THE COMMUNITY

In order to determine whether the children had learned to arrange places in their community according to the conventional system of fixed directions, Test III was incorporated in this investigation. The test required that the subjects give the location in terms of fixed directions of familiar places in either of two trading centers which were in the region in which the school were located. The items dealt with the following: (A) locating stores, public places, etc., by telling on which side of the street each is found, (north, east, etc.); (B) giving the direction of principal streets; (C) giving the direction seats face in theaters, auditoriums, etc., (D) sketching a map to show how certain public buildings, parks, etc. are arranged in space.

It was not expected that any one child would be familiar with all the places referred to in the test. In order to determine which of the places were within the experiences of each child, the lists of places were read orally by the examiner while each child crossed out those places with which he was unfamiliar. To help the children decide which of the places should be crossed out, the examiner made such statements as the following—"Cross out those places you could not easily find if your were in -----" "Could you go right to Mack's store if you were in ----- " When this was completed the subjects proceeded to give the location of those places remaining in the lists. Most of the subjects elected to use the list which related to the larger trading center—Ann Arbor. Consequently all results presented here relate to this center.

Locating familiar buildings. The first list includes such places as stores, banks, theaters, and recreation centers. Over half of the places were attempted by three fourths of the subjects. The average percentage of places attempted was 68 for the boys and 66 for the girls. However, both groups were very inaccurate in their locations: the boys succeeded in locating 23 per cent correctly while the girls only located 12 per cent correctly. The most familiar place and the most often located correctly was a national chain store. Places on intersections were especially troublesome as the subjects had difficulty expressing locations involving two directions.

Direction of streets and bridges. The second part of the test called for giving the direction of streets and bridges. Over 80 per cent of the subjects were familiar with the streets in the test and succeeded in giving a higher

percentage of correct responses than were given in the preceding part of the test. The boys were correct on 54 per cent of their responses and the girls succeeded in giving correct responses in 43 per cent of the cases.

Seats in the theaters. The third part of the test required that the subjects give the direction they face when seated in theaters and auditoriums. It proved difficult for the subjects to handle these exercises. Less than a third of the attempts were correct for the best known theater. The girls again proved less able than the boys. The former responded correctly on only 17 per cent of the attempts while the boys were correct in 20 per cent of the cases.

Mapping. In the fourth part of the test the subjects were required to make a map showing the spatial arrangement of well known places within the city limits. The list included such places as a stadium, a hospital, fair grounds, etc. The test was scored by using the stencil described in an earlier test. Slightly over half of the subjects attempted to locate the places, with 16 per cent of the boys and 11 per cent of the girls succeeding in their attempts.

The construction of the map caused considerable difficulty for the subjects, particularly in the arrangement of places according to fixed directions when the subjects faced in a direction other than north. For example, it was confusing for a child facing south to make a map with north at the top. A few subjects avoided this confusion by turning the test paper around so that north on the map coincided with the space direction, north, in other words, they oriented the map.

The results of the four sections of the test show that the subjects had for the most part failed to arrange places familiar to them into the conventional pattern of directions. The responses were inaccurate and often contradictory. Even though the subjects claimed they were familiar with the places and attempted answers, they did not exhibit control over the use of conventional directions.

ABILITY TO MAINTAIN ORIENTATION DURING TRAVEL

Some skill in orientation is necessary when traveling. The degree and kinds of skill needed are not well known. A person may travel extensively without making use of the cardinal directions. He may be guided by a general appreciation of the spatial relations between fixed objects, or between his position and his home or other familiar places.

Some persons use the type of orientation in which the self is at all times oriented in terms of the cardinal directions. These fixed directions constitute a "framework", in which the individual relates himself and other subjects.

In order to determine which type of orienting ability children would exhibit when tested in the out-of-doors, a field test was included in this investigation. The test required actual travel over relatively unfamiliar territory. The specific purposes of the test were to determine (1) whether the subjects would orient themselves in terms of cardinal directions or with reference to familiar objects, (2) the extent of the subjects' ability, and (3) the factors influencing the maintenance of orientation during travel.

Two routes of travel were selected in a residential section of Ann Arbor. The routes were approximately two miles in length. One followed a rather involved course, including a complete circle while the second route included all right angle turns and was slightly shorter than the first.

For purposes of testing and as points of reference, three stopping places were planned on each route. They divided the route into approximately three equal parts and formed an "L" with the third stop at the "toe" of the "L". This meant that the three points of reference were in a simple patterned relationship which, it was hoped, would be appreciated by the subjects if they maintained their orientation during the trip.

The subjects were taken in groups of four from their schools and driven over the route by the examiner. Before each group left their school, the cardinal directions were reviewed until everyone seemed oriented. The general purpose of the test was explained. The car was driven to the starting point of the route. Then the subjects were told they had now reached the beginning of the route. A rate of approximately 20 miles per hour was maintained during the travel. When the point designated as Stop 1 was reached, the car was stopped while the subjects noted the location. They were asked to note the direction of the streets, the surroundings, etc., in order that they might remember the "stop." A small gum label was provided for each child upon which he sketched the street pattern and charted by an arrow the direction he faced while at the stop. When this was completed, the car was driven to Stop 2 and a procedure similar to that just described was followed. In addition the children were asked the location of Stop 1 with reference to their present position, Stop 2. In order to obtain

an objective record, a pattern of arrows similar to that used in Tests I and II was used. The cardboard upon which the arrows were drawn was temporarily placed in the ceiling of the car and each child made a notation as to the particular arrow which pointed toward Stop 1.

After this exercise, the purpose of which was to determine whether the children were oriented with reference to Stop 1, travel over the route was continued. At Stop 3 the subjects were asked to answer in writing a set of questions dealing with the direction they were facing at each stop and direction to their right, left, and behind them; the direction in terms of an arrow between the stops and their reasons for believing their answers were correct. However, on the second series of tests, i.e. travel on Route 2, the questions were answered at each stop in place of waiting until the end. The subjects then placed the sketches they had made of the stops upon a circular piece of paper in what ever spatial arrangement they considered correct. This sketch was intended to reveal whether the subject appreciated the pattern of the three stops and the direction he faced at each stop.

The results are based upon four sources of information (1) answers to the questions (2) analysis of the sketches (3) observations of children during travel and (4) introspective report. The results are subject to the limitations of small sampling since 33 children were taken over Route I and 25 over Route II. No child was taken over both routes since the second route was planned after it became apparent the first was too difficult for the subjects. Approximately 50 per cent of the total number were correctly oriented at Stop I but about half of these or less than 25 per cent remained oriented until they reached Stop 3. Orientation was maintained throughout the entire trip by eight, or 25.4 per cent of the 31 boys, and five, or 18.5 per cent of the 27 girls.

It is interesting to note that 50 per cent of the subjects were lost so far as fixed directions were concerned before they ever reached the first stop, even though they were aware of their directions as they left their schools.

In order to determine whether the subjects appreciated the pattern of the route independent of cardinal directions, the two tests referred to earlier were used: (1) indicating directions by designating the arrow which pointed out the places in question, and (2) making a sketch to show the general pattern of the Stops of the route.

Considering first Route I, five of the sixteen boys and four of the seventeen girls, while at Stop 3, were able to choose the arrows which pointed in the general direction of Stops 1 and 2. Some subjects were able to point out one of the stops but not the other. In general, Stop 2 was more often pointed out correctly than Stop 1.

The sketches made by the subjects who traveled over Route 1 showed that two of the sixteen boys and four of the seventeen girls were able to show the correct spatial relations of the three Stops.

Route II was easier to follow, as can be seen by the fact that ten of the fifteen boys and two of the ten girls while at Stop 3, were able to designate the arrows which pointed to Stops 1 and 2; 50 per cent of the subjects appreciated the spatial arrangement of the three Stops. As for the sketches, twelve of the fifteen boys and three of the ten girls made drawings which showed the general arrangement of the Stops. Of these fifteen subjects only five were included in those who pointed out the stops by use of the arrows. The factor of guessing, undoubtedly, operated to influence the results.

Perhaps the designation of the three Stops tended to break the trip into three more or less independent experiences and led the subject to ignore the larger aspects of the route. It is possible that a better showing would have been made if the examiner had specifically warned the subjects beforehand that they would be asked to show the arrangement of the stops. This, however, might have had the effect of causing them to pay too much attention to details such as curves, number of turns, etc. As will be pointed out later, such detailed attention is likely to lead to confusion, especially if a series of changes occur in rapid succession or in case of a brief lapse of attention.

It was thought that the position of the sun in the sky might give the children a cue as to directions. Therefore, 22 of the 58 subjects were taken on days which were classified as sunny. Of these 22 subjects, seven reported making use of the sun; however, only two of these seven subjects succeeded in giving the correct directions at all three Stops. Those subjects who had reported in the interview at the end of the route that they did not use the sun were urged to make use of it to ascertain whether they were oriented with respect to cardinal directions. This suggestion was made to fifteen subjects. Eleven reported that they could not tell directions by the use of the sun. Four tried, but only one succeeded. The observation of the subjects

during the testing definitely indicated that the sun was not an important consideration in their orientation. There was evidence of lack of experience and practice in using the sun for such a purpose.

It was apparent during the testing that rapid shifts in the direction of travel proved confusing. There was a tendency for the subjects to "keep track", as they expressed it, by a sub-vocal rehearsal of the directions as they traveled along. A sudden turn or a lapse of attention resulted in the subjects losing their "train of thought." The process was much like that found in adding a column of figures, when a lapse of attention causes one to lose the subtotal before all the numbers have been added. The children were too much concerned over minor variations in the direction of travel and not enough concerned over the general pattern of the route.

Some of the subjects resorted to interesting devices to assist them in maintaining their orientation. Two boys reported using a pencil as a pointer and keeping it in a known direction throughout the trip. For example, one of them pointed his pencil to the north as the car left his school. Every time the car made a turn he then turned his pencil the number of degrees necessary to keep it pointing to the north.

One girl said she made use of her thumb nail, by writing on it the direction in which she was traveling. When the car turned a corner, she would rub her index finger across her thumb nail to erase the old record and would then write the new direction. Such tricks suggest that the task was rather difficult and invited the use of special aids.

COMPOSITE SCORE

The several tests of the series all dealt with the general topic of orientation, but each differed materially from the other. The information called for on the tests came from two major sources, (1) formal study of geography and (2) experience and travel in the local community. The locations of the "distant" cities had to be learned largely from maps, while the locations of neighboring cities, the spatial arrangement of places and streets in the child's trading center, had been acquired from direct experience with the places, or with the roads, streets, etc., leading to them.

In order to get a general index of the abilities measured by the tests, a composite score for each child was worked out. The composite score was derived from the results of Tests I, II-A, and III. In deriving the composite

score, the standard deviation for the scores of each test was used to, determine weighting. The sigma for Test II-A was taken as a base and the weighting for the other two tests was figured in terms of the ratios of their sigmas to this base.

The distributions of the weighted scores was fairly normal. The range of scores is marked—from 5 to 185. The superiority of the boys over the girls is again evident. Six girls received scores below the lowest score of the boys and three boys made scores which exceeded the best score made by the girls. The means and sigmas of the composite scores are given in Table IV.

TABLE V
MEAN COMPOSITE SCORES AND STANDARD DEVIATIONS FOR BOYS
AND GIRLS ON TESTS I, IIA, AND III

Sex	Mean	S. D.	Critical Ratio
Boys.....	82.9	34.65	4.75
Girls.....	60.7	33.15	

CONCLUSIONS

On the basis of the specific findings already presented in connection with the discussion of each test, the writer submits the following general conclusions:

1. Evidence has been presented to show that children do not have a well-generalized notion of the cardinal directions. They may, for example, identify south and east, but fail to identify southeast. They find it very difficult to use directions correctly in describing locations of places, etc., in their trading centers. However, when asked to point out locations of cities in space they are frequently fairly accurate—especially with near-by cities.

2. There is little evidence that children have had the necessary preliminary exercises and experiences which help them in learning directions and fixing the conventional pattern in mind. That east is opposite west is not any too well known by many children who are supposed to be reading locations from maps daily.

3. The test results show marked individual differences in orientation of children. The boys respond more frequently than do the girls and, taken

as a group, are superior. In most cases, however, the girls who do respond to exercises are nearly as accurate as the boys.

4. The direction the subjects face while taking the tests is an important factor in their success. A north-facing group is distinctly superior. A south-facing is inaccurate and exhibits definite incorrect "imaginary maps."

5. The results of the tests show that many children have two frames of reference—a conventional map frame for distant places and a "direct experience" frame for relatively near-by places. Two cities, one distant and one nearby, may be located in directions which are inconsistent with each other. A child seated in a west-facing position may indicate that Detroit is back of him; i.e. to the *east* and at the same time place Los Angeles to his left; i.e. to the *south*. His "experience frame" was used in the case of Detroit, and an incorrect "map frame" for Los Angeles. This may be done without recognizing the inconsistency.

6. One can conclude that children do not *know* directions: they *compute* them. That is, if a child were asked to point northeast, he is likely to respond by calculating much as if he were asked to add two numbers. He is likely to say, "There is north (pointing), there is east, so northeast is there -----"

7. Those persons who have well-developed abilities with regard to orientation seem to have the cardinal directions related to their bodily position at any given time. The pattern of arrangement of the cardinal directions needs to be as well fixed as the associations of right-left and front-back.

IMPLICATIONS

The results of this study carry certain implications for the teaching of directions:

1. There is real need for out-of-door exercises, observations, and drills with regard to directions. Children lack the foundational experiences necessary to make directions in space meaningful.

2. There is need, if directions are to function as instruments in orientation, to develop in the child a close relationship between the arrangement of cardinal directions and self. True, he may become lost, but once he has identified a *single* direction, the rest of the pattern will come as second nature.

3. Experiences in all sorts of positions should be provided in order that the pattern become sufficiently generalized that one position is no more advantageous than another. If a child has repeated experiences with the map even though correctly oriented, he is likely to be annoyed if he is put in a situation which demands the use of a map in some position other than that which he has come to prefer. As a consequence, he insists upon turning the map to put it in his favored position. For example, in the event he insists on the top being to the north, and he is reading a road map while riding in a car, in all directions excepting north, he must always turn the map. If he is facing in a south-facing position he must read his map in an upside-down position.

4. The teachers must assume a great share of the responsibility for the proper orientation of the children under their instruction. During the testing the writer found instances where teachers confessed inability to state the directions in which children were facing.

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